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A Crowding-based Model of Social Carrying Capacity: Applications for Whitewater Boating Use

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Following the Limits of Acceptable Change planning framework, we apply crowding standards proposed by Shelby, Heberlein and Vaske (1989) to develop a crowding-based model of social carrying capacity. Fourteen hundred and seventy boaters (347 commercial guided, 873 commercial non-guided, 28 private rafters, and 222 private canoers/kayakers) on the Nantahala River in North Carolina completed an on-site survey immediately following their white-water trip in the summer of 1994. There were four types of predictor variables: total daily use levels, water release level, time of day, and day of the week. The dependent variable was perceived crowding. Using an ordered logit model, all coefficients were significant at $p < .05$. Regression results were then applied to aggregate values to determine carrying capacities for three different crowding standards. Opportunities for applying and expanding the model to other settings and implications for management are discussed.

KEYWORDS: *social carrying capacities, recreational crowding, whitewater boating, limits of acceptable change*

Introduction

As use of public recreation resources grows, managers are increasingly faced with the prospect of limiting use to protect the resource, the recreation experience, or both. Managers usually recognize that such limits should be based on the resources' physical and social carrying capacities. Unfortunately, for social carrying capacities, managers often do not have the data or tools to link controllable use variables with salient capacity measures. In this paper we develop a model of perceived crowding that managers can use to set an acceptable range of social carrying capacities for whitewater boating. In doing so, we include in our model only predictors for which data are readily observable.

For the past 20 years, carrying capacity research has been an important area of inquiry for outdoor recreation researchers and managers. Traditional research assumed that capacities were reached when users perceived the setting as crowded (Heberlein, 1977). Based on this assumption early studies

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[1]It should be noted that encounter measures other than use levels may hold promise for establishing encounter norms in high density settings, including percent of time in sight of others, proximity to other users and/or waiting time at rapids, put-in or take-outs. We did not measure these variables in our study.

identified factors hypothesized to influence perceived crowding, including density and use levels (Hammitt, McDonald, & Noe, 1984), encounter preferences (Ditton, Fedler, & Graefe, 1983), tolerance norms (Stankey, 1973) and experience expectations (Gramman, 1982; Schreyer & Roggenbuck, 1978). Unfortunately, while most studies agreed that perceived crowding could be better explained by including both situational and psychosocial factors, the relative effect of these variables was less clear. Some reports indicated that social and psychological factors could explain more of the variance in crowding than use levels (e.g., Shelby, 1980), while others suggested use levels were either equally, or more important than user evaluations and expectations (Hammitt et al., 1984; Heberlein & Vaske, 1977). Use levels, for example, have been shown to account for between 4% to 43% of the variance in self-reports of perceived crowding (Graefe, Vaske, & Kuss, 1984; Hammitt et al., 1984; Manning, 1985).

More recently, social carrying capacity research has focused on establishing evaluative standards for acceptable use levels. One approach to developing these standards has involved the measurement of encounter norms; i.e., users have been asked to specify an acceptable or tolerable number of encounters (e.g., Patterson & Hammitt, 1990; Roggenbuck, Williams, Bange, & Dean, 1991; Shelby, Bregenzer, & Johnson, 1988; Vaske, Shelby, Graefe, & Heberlein, 1986; Whittaker & Shelby, 1988). While the normative approach holds considerable promise for establishing boating use capacities, we did not include encounter norms in our model for two reasons. First, it has been suggested that encounter norms may exist only under specific situational conditions (Patterson & Hammitt, 1990) and may be less useful in high density settings (such as the site selected for the present study) than low density conditions (Shelby & Vaske, 1991; Whittaker, 1990). Roggenbuck et al. (1991), for example, found that rafters were almost twice as likely to specify encounter norms for a wilderness whitewater trip than a social recreation experience. However, even for wilderness whitewater opportunities, fewer than 67% had norms about encounters. Second, there exists some concern in the research literature over how norms should be measured. Noe (1992) and Roggenbuck et al., (1991), among others, have argued that encounter norms should reflect social approval or disapproval governing behavioral actions; i.e., what other people think users should or should not do under a given social situation. Previous norm-encounter studies, however, have typically measured personal preferences for a particular social setting and subsequently aggregated these to form a social norm (Shelby & Vaske, 1991).

One alternative to the normative approach is to identify evaluative standards based on perceived crowding levels (Shelby & Heberlein, 1986; Shelby, Vaske, & Heberlein, 1989). Shelby et al., for example, have proposed crowding standards using a single-item 9-point perceived crowding scale ranging from "not at all crowded" to "extremely crowded." Of those users who indicated a score of 3 or greater, five categories of crowding were proposed: "suppressed" crowding (where less than 35% of users reported a rating of 3 or greater), "low-normal" (35-50% reported a rating of 3 or greater), "high-normal" (50-65% reported a rating of 3 or greater), "more than capacity" (65-80% reported a rating of 3 or greater), and "much more than capacity" (80-100% reported a rating of 3 or greater). The crowding categories suggest opportunities that range from primitive-type experiences (under "suppressed" crowding) to high-density experiences (when crowding is either "more than capacity" or "much more than capacity").

While the approach by Shelby et al. (1989) is intuitively reasonable, it assumes an arbitrary assignment of a rating of 2 as a crowding threshold. In addition, the percentage cut-offs for the five categories are also arbitrary. In other recreation situations and settings, evaluative standards based on the same 9-point scale may employ different or multiple crowding thresholds and category definitions depending upon the nature of the resource (e.g., primitive or developed) and user characteristics (numbers of users, experience levels, activity-type, group size, etc.). In this paper, we use three different evaluative standards, including two categories defined by Shelby et al.

A Crowding-based Model of Recreational Social Carrying Capacity

Following the Limits of Acceptable Change (LAC) framework (Stankey, et al., 1985), carrying capacities should reflect management objectives and evaluative standards (Graefe et al., 1984; Shelby & Heberlein, 1986; Stankey & McCool, 1984). In the case of social carrying capacities for river use, management objectives define the desired recreation opportunity to be provided (e.g., primitive/low density to developed/high density) and evaluative standards refer to acceptable levels of impact (e.g., desired crowding conditions). Table 1 shows evaluative standards for a range of management objectives ("suppressed" to "much more than capacity") using Shelby et al.'s (1989) proposed crowding categories. Consistent with the LAC framework, the standards are expressed in terms of probabilities (Stankey et al.).

Our model also recognizes that recreation planners and managers require carrying capacity formulations that are flexible and that reflect the multiple influences on management decisions regarding use levels (Man-

TABLE 1
Management Objectives and Evaluative Standards for Perceived Crowding Levels[1]

Management Objectives	Evaluative Standards[2]
Suppressed crowding	0-35% > 2.0
Low-normal	35-50% > 2.0
High-normal	50-65% > 2.0
More than capacity	65-80% > 2.0
Much more than capacity	80-100% > 2.0

[1]Taken from Shelby, Vaske and Heberlein (1989).
[2]Expressed as probabilities using a 9-point crowding scale.

ning, 1985). Increasing demands from outfitters for user permits, political pressure from interest groups, variations in natural resource conditions, and agency directives as well as user preferences require that any given recreation opportunity is associated with a range of acceptable use conditions. Table 1 suggests a range of standards that are associated with each management objective so as to allow greater managerial flexibility in setting use levels. For example, when managing for low density recreation opportunities (i.e., "suppressed" crowding), use levels can be in a range such that zero to 35% of the boaters perceive the setting as crowded.

The purpose of this study was to develop a crowding-based model that managers can use to set an acceptable range of carrying capacities for whitewater boating use. Although the model can be modified to incorporate multiple variables that may affect users' perceptions of crowding (including encounter norms, experience expectations, perceived encounter levels, etc.), we include only four types of independent variables: (a) total daily use levels by user-type (guided commercial boats, non-guided commercial boats, private rafts and private kayaks/canoes), (b) water release level, (c) time of day boater reached the final stretch of the river (before noon, early afternoon, mid afternoon, and late afternoon), and (d) type of day (weekend/holidays and weekdays). It is expected that these variables should be easily obtained and/or readily available to managers through daily counts and outfitter records.

Methods

Subjects and Sample Area

Boaters on the Nantahala River in North Carolina were sampled during the 1994 summer season (Memorial Day to Labor Day). The Nantahala is a dam-controlled river dependent on releases determined by the Nantahala Power and Light Company (NPLC). The river affords a 10-mile float that takes about 4 hours and is comprised of mostly Class I and II rapids, along with several short Class III rapids. (Class I is rated as least difficult and Class VI as most difficult.) As a result it is a popular trip for families and beginner rafters, providing a high-use density recreation experience. Over 200,000 people float the river each year.

Sampling was conducted close to the take-out and between the hours of 10:00 a.m. to 6:00 p.m. on 38 days (25 weekdays and 13 weekends including holidays) during the season. Boaters were sampled by first selecting the next available watercraft and then randomly choosing one boater from each craft. When selecting the next available watercraft, preference was given to private users (when possible), since they represent less than 12% of total annual use on the river.

Data Collection

An on-site survey was administered to sampled boaters to measure perceived crowding on the river and record the type of craft used. Heberlein and Vaske's (1977) 9-point uni-polar scale from 1 "not at all crowded" to 9 "extremely crowded" (with interior points of "slightly crowded" and "moderately crowded") was used. This is the same scale that Shelby et al. (1989) applied to develop crowding standards. The 9-point scale has been shown to be reliable across on-site and mail-back administration and has demonstrated validity across various use settings (e.g., perceived crowding is greater for high versus low density situations, peak versus non-peak time periods, etc.).[2]

Fifteen hundred and thirteen boaters were contacted on-site. Forty three surveys were either illegible or contained missing responses to the type of craft and/or perceived crowding questions, yielding a final sample size of 1470. Of these usable surveys, 23.6% (n = 347) were guided commercial boaters (of which 317 were in rafts), 59.4% (n = 873) were non-guided commercial boaters (of which 820 were in rafts), 1.9% (n = 28) were private rafters, and 15.1% (n = 222) were private users in canoes or kayaks.

On the same days that the on-site survey was conducted a total daily count of boaters (from 10:00 a.m. to 6:00 p.m.) was undertaken by a trained Forest Service volunteer. Counts were taken at the approach to the final rapids (a location within 100m of the take-out). The time of day and the day of the week the count was taken were also recorded. Boaters were identified according to whether they were guided commercial, unguided commercial, private rafters or private kayakers/canoers. Data on average daily water release (expressed in units of cubic feet per second) were provided by the NPLC.

The total daily count of boaters on the sample days was 78,773; of these, 36.3% (n = 28,574) were guided commercial boaters, 51.9% (n = 40,909) were non-guided commercial boaters, 2.9% (n = 2,277) were private rafters, and 8.9% (n = 7,013) were private kayakers/canoers. Over the sampled weekdays, the average daily count for commercial use (guided and non-guided) was about 1,335 persons, and about 200 people for private use (rafts, kayaks and canoes). On weekends, the average counts were more than twice as high. The average weekend commercial use was just over 2,700 people, and about 425 private users.

The daily counts showed that the types of users and their temporal distribution also differed between weekends and weekdays. On weekdays, 49.5% of all users were rafters, compared to only 33.7% on weekends and holidays. On weekdays, 19% of users completed their trip before noon, 26.8% between noon and 2 p.m., 39.9% between 2 p.m. and 4 p.m., and 14.3% after 4 p.m. On weekends, 17.8% of users finished their river trip before noon, 36.2% between noon and 2 p.m., 27.8% between 2 p.m. and 4 p.m., and 18.2% after 4 p.m.

[2]Refer to Shelby et al. (1989) for a more complete discussion of reliability and validity estimates of the perceived crowding scale.

Analysis

Regression on crowding ratings. Individuals' perceived crowdedness ratings were reported along a 9-point ordinal scale. We assumed these observed ratings were generated by the following ordered logit[3] model:

$$Z_i = \beta' X_i + e_i$$

where Z_i is the unobserved true perception of crowding on the river for individual i, and e_i follows a standard logistic distribution.[4] The observed perceived crowdedness rating for the individual, Y_i, is related to Z_i as:

$$\begin{aligned} Y_i &= 1 \text{ if} \quad Z_i \leq 0 \\ Y_i &= 2 \text{ if} \quad 0 < Z_i \leq \mu_1 \\ Y_i &= 3 \text{ if} \quad \mu_1 < Z_i \leq \mu_2 \\ \ldots\ Y_i &= 9 \text{ if} \quad \mu_7 < Z_i \end{aligned}$$

That is, the value of the observed rating is determined by the value of the unobserved construct in relation to a set of threshold levels (μ_1 to μ_7). Note that an observed crowding level of 4 indicates more, but not necessarily twice as much, crowding compared to an observed level of 2. Thus, observed levels are ordinal scaled.

The vector of regressors, X_i, includes a constant and nine other variables:

MORNING = indicator variable (= 1 if the person was contacted before noon);

EARLYAFT = indicator variable (= 1 if the person was contacted between noon and 2 p.m.);

LATEAFT = indicator variable (= 1 if the person was contacted after 4 p.m.);

NONCOM = indicator variable (= 1 if the person was a noncommercial user);

WEEKEND = indicator variable (= 1 if visit occurred on weekend or holiday);

RAFT = indicator variable (= 1 if the person used a raft);

COMMUSE = number of commercial users on the river the day the individual visited;

PVTUSE = number of private users on the river the day the individual visited;

[3]It is important to note the difference between an ordered logit model and a multinomial logit model. In the multinomial logit, the choices represent discrete but unordered choices, such as between using alternative modes of transportation, or choosing among a set of recreation sites. The ordered logit model assumes ordinal relations exist among the observed choices.

[4]We fit both an ordered probit (which assumes a standard normal error term) and an ordered logit model. The logit specification provided a superior fit to the data. hence, we only report those results.

CFS = mean water release from Nantahala Dam in cubic feet/second for the day the individual visited.

Indicator variables were used to account for differences in crowdedness ratings across user types (NONCOM, RAFT), type of day (WEEKEND), and time of day (MORNING, EARLYAFT, LATEAFT). Higher water levels allowed faster and more difficult rapids, and overall faster trips downriver. Use levels were the variables of primary interest, although on the Nantahala, only commercial use levels are controllable. Parameters, β, and thresholds, μ, were estimated via maximum likelihood techniques, using the ordered logit procedures in LIMDEP 7.0 (Greene, 1995).

Results are presented in Table 2. All variables were significant at the $p = .05$ level, and all but LATEAFT and CFS were significant at $p = .01$. Signs on the coefficients indicate that noncommercial users and weekend users perceive greater levels of crowding compared to commercial users or weekday users, when other variables are held constant. Rafters perceive lower crowding levels than do non-rafters. Taken together, the time of day variables indicate that perceptions of crowding increase as the day wears on, even though fewer people finish their trip after 4 p.m. than between 2 p.m. and

TABLE 2
Ordered Logit Regression Coefficients of Perceived Crowding

Measure and Variable	Coefficient	T-ratio	p
Regressors			
Constant	2.6402	5.68	<.001
MORNING	−2.6174	−12.56	<.001
EARLYAFT	−0.4393	−3.98	<.001
LATEAFT	0.2753	2.10	.036
RAFT	−0.3828	−3.41	<.001
NONCOM	0.3818	2.67	.008
WEEKEND	0.4584	3.53	<.001
CFS[1]	−0.0020	−2.47	.014
PVTUSE	0.0011	2.71	.007
COMMUSE	0.0006	8.31	<.001
Thresholds			
1	1.1115		
2	2.1896		
3	2.7501		
4	3.7862		
5	4.4978		
6	5.6047		
7	7.0967		
Chi-Square		667.39	
Log-likelihood		−2783.69	
Pseudo R^2		.37	

[1]Water release was measured in cfs and ranged from 408 to 614.

4 p.m.. As expected, the signs on numbers of users of both types are positive, indicating that greater levels of use are associated with greater levels of crowding. Higher water flows contribute to reduced perceived crowding levels.

Predicting crowding levels. We used the regression results to predict the distribution of crowding ratings under various use conditions. Distributions were predicted separately for weekends and weekdays, primarily because of differences in the temporal distributions, proportion of rafters, and ranges of private and commercial use levels noted earlier. For any day, the predicted percentage of river users with each reported crowding level is based on the logistic cdf (Greene 1995):

$$\Pr[Y] = j] = F[(\mu_{j-1} - X'\beta)/\sigma] - F[(\mu_{j-2} - X'\beta)/\sigma]$$

where:

$\mu_{-1} = -\infty$;
$\mu_0 = 0$;
$\mu_8 = +\infty$;
σ = the standard deviation for the logistic distribution;
F(.) = logistic cdf = exp(.)/[1 + exp(.)] ;
β = vector of estimated regression coefficients.

The formula shows that the predicted percentage of river users with each crowding level is the value of the logistic cdf between the appropriate thresholds. The values for variables in the vector X include the weekday or weekend daily averages (as appropriate) for RAFT, MORNING, EARLYAFT, LATEAFT, and PVTUSE. That is, for a weekday, the value for RAFT is 0.495, and for a weekend, 0.337. WEEKEND, of course would take the appropriate indicator value. Values for CFS and COMMUSE are treated as absolute variables to allow us to examine the distribution of crowding ratings at different combinations. The value for the indicator variable NONCOM is the probability of drawing a noncommercial user at random from the population of users for the day (= PVTUSE/(PVTUSE + COMMUSE). As an example, Table 3 shows the predicted distribution of crowding ratings on both weekdays and weekends at a flow of 500 cfs. We show crowding distributions for three levels of commercial users that include the average use for that type of day (rounded to the nearest hundred) and that use level plus or minus approximately one standard deviation. Time of day, private use, and boat type variables take the appropriate mean values for that type of day.

Table 3 shows that for weekdays, increased commercial visitation reduces the predicted proportion of visitors with crowding ratings of 1, 2 or 3. Similarly, the proportion predicted for each crowding rating above 3 increases as commercial use goes up. For weekends, increases in commercial use result in reduced proportions of visitors with crowding ratings below 5, and increases for each rating of 6 or higher.

TABLE 3
Predicted Percent Distribution of Crowding Ratings on Weekdays and Weekends for Three Commercial Use Levels[1]

Crowding Rating	Weekday Commercial Use			Weekend Commercial Use		
	700	1400	2100	1100	2700	4300
1	29.1	24.9	20.8	18.9	12.3	7.8
2	14.0	13.1	11.9	11.2	8.3	5.6
3	14.8	14.6	14.2	13.8	11.4	8.5
4	7.3	7.6	7.7	7.7	7.1	5.7
5	11.7	12.6	13.5	13.8	14.1	12.7
6	6.3	7.1	7.9	8.3	9.5	9.7
7	7.0	8.1	9.4	10.1	12.9	14.8
8	5.3	6.4	7.6	8.4	12.0	16.0
9	4.5	5.6	7.0	7.8	12.4	19.2

[1]Assumes a flow of 500 cubic feet per second and mean values for other variables.

Application of results. In and of themselves, the predictions for crowding ratings may not be useful to river managers. However, by combining the predicted levels for crowding with evaluative standards for management goals, the maximum commercial use levels for a variety of conditions could be identified. As an example, we examine the maximum commercial use allowed on weekdays for three different evaluative standards. These standards place a limit on commercial use at a level such that we would expect that: (1) no less than 35% of river users have crowding ratings less than 3 (Shelby et al.'s (1989) "high normal" standard); (2) no less than 20% of river users have crowding ratings less than 3 (Shelby et al.'s "more than capacity" standard); and (3) no less than 50% of river users have ratings below 5, the mid-point on the scale. The last of these three standards references a higher threshold on the 9-point scale, in recognition that the Nantahala represents a more developed and accessible site than those used in the Shelby et al. study.

For each standard, limits are determined for three different flow levels and five levels of private boaters (see Table 4). Consider weekdays where it is known that water flow will be at 600 cfs, and about 200 private users are expected. If the management goal is to keep crowding to a point where no less than 35% of river users have ratings below 3, the commercial use should be capped at 2,130. However, if the goal is to have at least half of the river users with ratings below 5, then the commercial cap would be 3,010.

The three standards lead to a range of use limits. The most restrictive standard has at least 35% of river users with crowding rankings below 3. This standard limits commercial use to between about 700 and 2,350 people per day, depending on water flow and private use level. The least restrictive standard ensures that no less than 20% of river users will have ratings less than

TABLE 4
Daily Commercial Use Capacities for Three Different Crowding Levels on Weekdays Based on Water Levels and Number of Private Boaters[1]

	# of Private Boaters				
Water Flow (cfs)	100	200	300	400	500
	35% of users with ratings 1 or 2 (Shelby et al. "High-normal" crowding)				
400	1680	1450	1220	970	710
500	2020	1800	1570	1340	1100
600	2350	2130	1920	1700	1470
	20% of users with ratings 1 or 2 (Shelby et al. "More than capacity" crowding)				
400	4000	3800	3600	3390	3190
500	4330	4130	3930	3730	3520
600	4660	4460	4260	4060	3860
	50% of users with ratings 1 through 4				
400	2550	2340	2120	1910	1690
500	2880	2670	2460	2250	2030
600	3210	3010	2800	2590	2380

[1]Figures are rounded to the nearest 10 commercial users.

3. For this standard, commercial use will be between about 3,200 and 4,660 users per day.

In general, an additional 100 cfs increases the commercial use capacity by 330 to 360 people per day, across all standards and private use levels. Each additional 100 private users reduces the commercial use cap by about 200 people for the two less restrictive standards. However, when at least 35% of users are to have ratings below 3, then each additional 100 private users reduces commercial use by between 220 and 260 people.

Discussion and Conclusions

We have proposed a framework that managers can use to set an acceptable range of whitewater boating use based on user perceived crowding levels. Our approach is limited to conditions for which encounter norms may not exist for a majority of users (i.e., primarily high use density settings).[5]

[5]In related work, Tarrant and Cordell (in review) have found that only 38% of commercial boaters and 40% of private boaters on the Nantahala River were able to specify a maximum number of tolerable contacts.

Furthermore, we include only information about use levels, time of day, day of week and water release as predictor variables.

In our model, evaluative standards are developed using a single measure of perceived crowding. There are a number of concerns with this approach. First, perceived crowding is a psychosocial phenomena that has been found to be more strongly related to individual user characteristics than to situational conditions (Shelby & Heberlein, 1986). As a result, managers may be more likely to influence perceived crowding by modifying user expectations and preferences than necessarily by changing use levels.

Perhaps more importantly, the cut-offs recommended by Shelby et al. (1989) and the ones we highlight as examples of evaluative standards are arguably arbitrary. There is little empirical evidence that when more than 65% of users report a crowding level greater than 2 (on the 9-point scale) this reflects too much (or too little) crowding. The arbitrariness of the standards, however, does not invalidate our model. On the other hand, it does suggest that a range of standards must be developed and considered based on the needs of managers and characteristics of the resource.

The standards we used all had a single threshold. That is, for two of the standards all ratings above 2 were treated identically, as "crowded". For the third standard, ratings over 4 were indicative of crowding. As a result, crowding was effectively a dichotomous variable, and quite a bit of information from the logit model prediction was not used. One way to make greater use of the information would be to put a second threshold at the upper portion of the rating scale that accounts for the proportion of visitors who find the river "extremely crowded" (ratings of 8 or 9). Thus the evaluative standard might also include a restriction that not more than, say, 10 to 15% of users find the river extremely crowded. Such an upper end constraint might well be more appropriate for high density situations such as the Nantahala. Using two constraints in combination would allow greater use of the information on the distribution of crowding ratings that come from our logit model, and give managers greater flexibility in deciding on the binding use constraint. Fortunately, the analytical basis of our model is sufficiently flexible that use levels can be determined given any type of measurable standard. Improving evaluative standards to make fuller use of crowding responses and identifying the types of resources where different standards are applicable is an important area for future research.

Use levels, time and day, and water release variables explained 37% of the variance in perceived crowding. There are, however, other factors (especially social-psychological indicators) that may improve the R^2. While these additional variables were not included in our analysis, a useful extension of the current model would be to address the independent and interactive effects of both situational and personable characteristics on perceived crowding and ultimately on use limits.

Another limitation to the study concerns the potential for user displacement. Our results apply only to users who chose to recreate on the Nantahala and do not include users who previously boated the river but were displaced because of crowding or other factors. As a result, users in our study may have developed an acceptable level of crowding that is different from boaters on other rivers. This suggests that the results are not necessarily generalizable to the general population of participants in any given recreation activity.

Conclusions

The use limits proposed in Table 4 identify commercial use capacities for the upper range of "high-normal" and "more than capacity" crowding levels only, using the evaluative standards of Shelby et al. (1989). In addition, another standard that had at least half of the users with ratings below the mid-point of the scale was employed. Results in Table 4 highlight several important points. First, there appears to be an unequal trade-off between commercial and private users regarding their impact on crowding perceptions. Independent of the crowding standard, accommodating an additional 100 private users means reducing commercial use by between 200 and 260 persons.

Second, increasing water flow by 100 cfs has somewhat more of an effect on commercial use limits than decreasing private uses by 100 people per day. However, to be most effective in meeting acceptable commercial use limits, managers must have knowledge of, if not control over, *both* water release levels and the amount of private recreational use. Unfortunately, in many cases managers have at best limited control over either of these. Private companies often have final control over water releases, and non-commercial recreational use is often unregulated. Resource managers must balance protecting the quality of recreation resources and experiences with economic growth or value obtained from use of those resources. For dam-controlled rivers such as the Nantahala, results from carrying capacity and economic impact studies are essential for recreation managers to negotiate with power companies, outfitters, and other publics about the best use of impounded water for white-water boating, hydropower, and lake recreation (English, Bowker, Bergstrom, & Cordell, 1995).

Implicit in our model is that (1) there is agreement about the type of recreation opportunity to be provided and (2) the evaluative standards are valid indicators of crowding (i.e., they represent acceptable conditions for the desired type of recreation opportunity). In reality, however, there is often disagreement concerning specific management objectives for recreation opportunities, such as white-water rafting on the Nantahala (Manning, 1985). While land management agencies are slowly beginning to incorporate ROS techniques (Driver, Brown, Stankey, & Gregoire, 1987; Virden & Knopf, 1989), on-the-ground application requires consensus among multiple interest groups as well as users.

At this point, it is also unknown if the crowding standards proposed by Shelby et al. (1989) are realistic for most whitewater boating experiences. Although the standards provided recommended carrying capacities for "high normal" and "more than capacity" crowding levels that were within the range of current weekday use levels of the Nantahala, they might not be applicable in other recreation settings, such as low-density rivers, or rivers requiring more expertise to run. In particular, future studies are needed in which the model is applied to less developed river settings where a greater proportion of users are uncrowded.

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